



ARL-SR-0317 • MAR 2015



US Army Research Laboratory

# Wet-Bulb–Globe Temperature Data Report

by David P Sauter

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**by David P Sauter**

***Computational and Information Sciences Directorate, ARL***

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
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1. REPORT DATE (DD-Mar MM-YYYY) March 2015		2. REPORT TYPE Special Report		3. DATES COVERED (From - To) 11 Aug 2014–23 Aug 2014	
4. TITLE AND SUBTITLE Wet-Bulb–Globe Temperature Data Report				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) David P Sauter				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) US Army Research Laboratory ATTN: RDRL-CIE-D White Sands Missile Range, NM 88002-5501				8. PERFORMING ORGANIZATION REPORT NUMBER  ARL-SR-0317	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited.					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT The Wet-Bulb–Globe Temperature (WBGT) is used extensively by the US military (and others) to provide guidance for work and rest periods as well as water intake by Soldiers in a hot environment. In an effort to help validate a predictive WBGT algorithm in use in a heat-stress-guidance application, WBGT data measurements were performed at Eglin Air Force Base, Florida, in August 2014. The data and a brief data analysis are included in this report.					
15. SUBJECT TERMS Wet-Bulb–Globe Temperature, heat stress					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT  UU	18. NUMBER OF PAGES  20	19a. NAME OF RESPONSIBLE PERSON David P Sauter
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			19b. TELEPHONE NUMBER (Include area code) (575) 678-2078

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## Acknowledgments

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The author would like to acknowledge the 96<sup>th</sup> Weather Flight at Eglin Air Force Base, Florida, for its outstanding support before, during, and after the data-collection effort. Special thanks go to Mr. David Biggar, staff meteorologist with the 96<sup>th</sup>.

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## 1. Introduction

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The Wet-Bulb–Globe Temperature (WBGT) is used extensively by the US military (and others) to provide guidance for work and rest periods as well as water intake by Soldiers in a hot environment. In an effort to validate a predictive WBGT algorithm within a heat-stress-guidance application, WBGT-data measurements were performed at Eglin Air Force Base (AFB), Florida, in August 2014. A recent paper (Sauter 2013) provides details of the heat-stress-guidance application and the role of the WBGT. This report includes an overview of the instrumentation and site, the actual data, and a brief analysis of the data. The primary intent is to make the data available (an Excel spreadsheet of the data is available upon request).

## 2. Instrumentation and Site Overview

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The WBGT consists of 3 separate temperature components (Sauter 2013):

- Ambient dry-bulb temperature ( $T_d$ )
- Natural wet-bulb temperature ( $T_w$ )
- Black-globe temperature ( $T_g$ )

These values are typically measured directly as with the 3M QUESTemp<sup>°</sup> QT32 sensor (Fig. 1) or the Sigma Products tactical WBGT kit (Fig. 2).



**Fig. 1 3M QUESTemp<sup>°</sup> 32 Sensor**



**Fig. 2 Sigma Products tactical WBGT kit**

In the case of the Kestrel 4400 Heat Stress Tracker (Fig. 3), the natural wet-bulb component of the WBGT is computed as a function of the measured ambient temperature and humidity values.



**Fig. 3 Kestrel 4400 Heat Stress Tracker**

One each of the QT32, Sigma, and Kestrel sensors was used simultaneously in the data-collection process. Two each of the Sigma Products kits and the Kestrel 4400 meters were available and were interchanged approximately halfway through the data-collection period.

Data collection was conducted at Eglin AFB in a grassy and somewhat open area (Fig. 4). August was chosen in order to collect data in a hot and humid environment that lends itself to relatively high WBGT values and conditions favorable for heat-stress injuries. As the QT32 instrument is not designed to be exposed to precipitation, there are no observations for rainy conditions. Readings were generally taken every 30 min between mid-morning and late afternoon. A sampling duration of 60 s was chosen. The Kestrel 4400 sensor is able to automatically take samples every 2 s over the minute period and then display the average WBGT component values. For the Sigma WBGT kit and the QT32 sensor, the readings were taken immediately after the Kestrel readings were initiated and then again immediately after they were concluded. These values were then simply summed and halved to provide the average.



**Fig. 4** Eglin AFB's WBGT data-collection site

### **3. Data Analysis**

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Although not intended to be a complete and detailed analysis of the data, the following observations have been made regarding the measurements from the various instruments, some of which belonged to the US Army Research Laboratory (ARL) and some to the 96<sup>th</sup> Weather Flight.

- 1) Compared to the QT32 and Sigma instruments, the Kestrel 4400 Heat Stress Meter's derived  $T_w$  values are too high (4–6 °F or more) under conditions with significant, direct solar load on the instrument. The Nielsen–Kellerman Co. (manufacturer of the Kestrels) was contacted regarding this bias (Sauter

2014a) and modifications to the software that computes the  $T_w$  were made. Subsequent measurements will be made once the updated sensor is received.

- 2) Under conditions of high solar load and light wind speeds, the Sigma Products  $T_d$  values typically exhibited an 8–10 °F warm bias as compared to the QT32 and Kestrel devices (as well as to a National Weather Service measuring site located less than a mile away). This information was provided to a Sigma Products representative (Sauter 2014b). As a result, the author was provided 2 additional tactical WBGT kits that were painted white (one matte and the other glossy) instead of the dark green of the original sensor. Limited follow-on measurements with the white sensors indicated somewhat lower  $T_d$  readings, but still higher than expected. Additional observations are anticipated later in 2015.
- 3) Although the relative-humidity (RH) value is not used by the QT32 sensor in the computation of the WBGT, the value exhibits a significantly low bias (20% or more) under hot and sunny conditions. It is believed that this is due to the RH sensor being located inside the QT32 housing and not being adequately ventilated. This was reported to a 3M (manufacturer of the QUESTemp sensors) representative (Sauter 2014c) who concurred with the finding.

While at Eglin AFB, several readings from a second QT32 sensor (property of the 96<sup>th</sup> Weather Flight) were compared to the ARL's QT32 and provided nearly identical results. The QT32 sensor readings are considered the baseline values.

## **4. Data**

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The raw data from the Eglin AFB site are included in the following tables. Tables 1a–1c include the observations for Sigma sensor 1 and Kestrel sensor 2 while Tables 2a–2b include Sigma sensor-2 and Kestrel sensor-1 observations. An Excel spreadsheet of the data is available from the author upon request.

**Table 1a WBGT and Meteorological Data for Quest, Sigma 1 (S1), and Kestrel 2 (K2) Sensors**

Mon	Day	Hour	Min	Pressure millibars	SIGMA 1			QUEST			KESTREL 2			Wind mph	Cld amt tenths	Cld type code <sup>a</sup>	Obscuration code <sup>b</sup>	Quest RH %	Kestrel RH %	VPS <sup>c</sup> RH %	S1 WBGT deg F	Q WBGT deg F	K2 WBGT deg F
					Dry deg F	Nat Wet deg F	Globe deg F	Dry deg F	Nat Wet deg F	Globe deg F	Dry deg F	Nat Wet deg F	Globe deg F										
8	11	16	22	1013.2	94.5	80	110	88.7	80.6	111.5	87.8	86.4	111	3.5	3	2	0	51	73		87.5	87.6	91.5
8	11	16	56	1012.7	93.5	81.5	113.5	90	81.2	111.1	90	84.7	108.9	1.8	3	2	0	48	63	62	89.1	88.1	90.1
8	11	17	36	1012.8	94.5	80.5	110.5	91	80.8	112.4	90.1	83.7	113.2	2.3	3	2	2	41	58		87.9	88.1	90.2
8	11	18	15	1012.5	93	80.5	112.5	90.1	80.7	109.2	89.1	82	106.9	3.4	5	2	0	46	60	56	88.2	87.3	87.7
8	11	18	55	1012.1	91	80	101	88.7	81.2	101.5	88.9	83.3	100.9	1.8	5	2	2	51	68	68	85.3	86.0	87.4
8	11	20	0	1011.2	96.5	81.5	126	93	81.3	117.3	92.5	84.6	113	4.3	2	2	0	42	53	54	91.9	89.7	91.1
8	11	20	30	1011	95.5	81	114	92.3	81	107	92.3	82	104.7	3.2	3	2	0	42	54		89.1	87.3	87.6
8	11	21	0	1011	95	79.5	106.5	92.3	80.7	105.4	92.8	80.8	102.7	1.7	4	2	1	40	51	51	86.5	86.8	86.4
8	11	21	30	1011	93	78	106	91.4	79.9	101.4	91.9	81.7	103.3	1.4	4	2	2	42	55		85.1	85.4	87.0
8	12	14	20	1012.1	86	79	101.5	83.6	78.8	103.8	91.8	81.1	96.6	0.3	5	4	1	60	61		84.2	84.3	85.3
8	12	15	0	1011.9	89.5	80	112	86.5	80.1	110.4	92.1	85.8	104.4	0.5	5	4	1	41	62	74	87.4	86.8	90.2
8	12	15	30	1012.2	93	81.5	119.5	88.6	81.3	117.7	89.1	86	113.9	1.2	6	4	1	38	64		90.3	89.3	91.9
8	12	16	0	1011.9	95	80.5	118.5	89.6	81.3	117.2	89.1	86.4	118.2	2.2	7	4	1	35	64	70	89.6	89.3	93.0
8	12	16	30	1011.6	89	79	100	86.1	79.7	100.5	86.4	82.8	99.3	1.1	8	5	1	53	72		84.2	84.5	86.5
8	12	17	0	1012	88.5	79	101	86.2	79.6	101.1	86.4	82.2	99.3	1.2	9	5	2	53	71	70	84.4	84.6	86.0
8	12	17	30	1011.9	91	80.5	105.5	87.2	80.5	105.6	87.4	83.8	103.8	2	9	5	1	52	70		86.6	86.2	88.2
8	12	18	0	1011.8	93.5	80	115	89.5	80.5	113.4	89.1	85.1	113	2	8	5	1	43	64	64	88.4	88.0	91.1
8	12	18	30	1011.7	93	79.5	106.5	88.4	80.1	107.4	89.8	84	107.8	2	8	3	1	47	62		86.3	86.4	89.3
8	12	19	0	1011.1	96.5	80.5	117.8	90.9	80.6	117.6	91.2	85.8	116.1	2.7	5	5	0	42	59	62	89.6	89.0	92.4
8	12	19	30	1010.8	96.3	80	116	91	81	116.8	92.1	84.6	114.4	2.8	4	5	0	42	56		88.8	89.2	91.3
8	12	20	0	1010.2	95.3	80	113.8	90.7	80.8	113	91	84	111.6	2.7	5	5	0	42	58	59	88.3	88.2	90.2
8	12	20	30	1010.2	93.5	79	110.5	90.1	80.4	111.4	90.9	84.6	111.9	2	7	5	1	40	59		86.8	87.6	90.7
8	12	21	0	1010.5	94.3	80.8	113	90.5	81.3	114	91.8	85.5	113.2	2.7	6	5	0	43	59	62	88.6	88.8	91.7
8	13	14	30	1012.8	82.3	76.3	89.5	81.2	77.1	89.7	82.4	76.8	87.6	0.7	6	5	2	71	76		79.5	80.0	79.5
8	13	15	0	1012.9	86	78	108.3	84.2	79.1	110.5	82.8	82.9	108.9	2.1	5	5	1	49	75	79	84.9	85.9	88.1
8	13	15	30	1012.8	92	82	123	88.6	81.5	119.1	88.9	85.5	111.4	0.5	4	5	0	38	64		91.2	89.7	91.0
8	13	16	0	1012.7	96	80.5	121.5	90	81.5	121.8	91.4	83.8	113.2	0.1	3	5	0	39	53	66	90.3	90.4	90.4
8	13	16	30	1012.8	97.8	84.5	125.5	93.1	84.1	123.1	94.1	89.2	121.5	1.6	3	2	0	38	59		94.0	92.8	96.2
8	13	17	0	1012.7	99.5	84.8	125	93.6	84.1	122.4	94.5	88.5	115.9	2.4	3	2	0	39	58	66	94.3	92.7	94.6
8	13	17	30	1012.4	96.5	82.8	118.5	92.5	82.5	115.4	92.3	86.5	114.6	1.9	3	2	0	40	61		91.3	90.1	92.7
8	13	18	0	1012.3	97.3	83.8	117	92.3	83.4	115.6	91.9	86.4	113.7	2.2	3	2	0	44	61	66	91.8	90.7	92.4
8	13	18	30	1012	97	82.8	118.8	92.8	82.7	116.9	93.2	87.1	116.4	2.5	3	2	0	43	59		91.4	90.6	93.6
8	13	19	7	1011.3	98	82.8	115.3	92.9	82.9	116.2	92.5	86.4	116.4	2.8	3	2	0	44	59	66	90.8	90.6	93.0
8	13	19	30	1011.4	98	82.3	115.3	93.3	82.8	117.9	94.6	87.4	117.7	2.5	3	2	0	41	56		90.5	90.9	94.2
8	13	20	0	1011.1	95	81.5	108.8	91.6	82	109.7	92.1	84.7	110.3	2.9	3	2	1	46	59	66	88.3	88.5	90.6
8	13	20	30	1010.7	96.5	82.5	114.8	92.3	82.8	115.5	93.2	85.3	107.2	1.8	2	2	0	46	59		90.4	90.3	90.5

Notes: All observations were taken at 30.49° N, 86.52° W (Eglin AFB). Local time = GMT – 5 h.

<sup>a</sup> 0 = none; 1 = stratocumulus; 2 = cumulus; 3 = altostratus/altocumulus; 5 = thin cirrus; 6 = thick cirrus; 7 = precipitation.

<sup>b</sup> 0 = sun not obscured; 1 = sun partially obscured; 2 = sun obscured.

<sup>c</sup> National Weather Service observation site at the Northwest Florida Regional Airport (Valparaiso), less than 1 mile south-southwest of the WBGT observation site.

**Table 1b WBGT and Meteorological Data for Quest, Sigma 1 (S1), and Kestrel 2 (K2) Sensors**

Mon	Day	Hour	Min	Pressure	SIGMA 1			QUEST			KESTREL 2			Wind	Cld amt	Cld type	Obscuration	Quest RH	Kestrel RH	VPS <sup>c</sup> RH	S1 WBGT	Q WBGT	K2 WBGT
					Dry	Nat Wet	Globe	Dry	Nat Wet	Globe	Dry	Nat Wet	Globe										
		GMT		millibars	deg F	deg F	deg F	deg F	deg F	deg F	deg F	deg F	deg F	mph	tenths	code <sup>a</sup>	code <sup>b</sup>	%	%	%	deg F	deg F	deg F
8	13	21	0	1010.8	90.8	79.8	101	89.8	80.8	100.7	89.6	84	106.3	2.7	4	2	2	49	65	62	85.1	85.7	89.0
8	13	21	30	1010.7	94.3	80.5	111.5	91.6	81.4	112.5	92.3	85.5	113.4	3.3	3	2	0	44	58		88.1	88.6	91.8
8	14	14	0	1014.1	85	72.8	103.8	84	73.2	104	83.1	76.3	104.9	2.9	2	5	0	39	55	55	80.2	80.4	82.7
8	14	14	30	1014.2	88.5	73.5	106.5	85.6	74.6	107.9	86.2	77.9	107.4	2.8	2	5	0	35	50		81.6	82.4	84.6
8	14	15	0	1014.2	89.5	73.8	108	86.8	74.6	107.8	86.7	78.6	108.7	2.4	3	5	0	34	51	52	82.2	82.5	85.4
8	14	15	30	1014.3	93.3	74.8	113.5	89	75.6	113.9	88.3	79.9	113.7	2.1	3	5	0	31	48		84.4	84.6	87.5
8	14	16	0	1014.4	94.8	77	116.5	91.2	77.7	116.2	93	79.9	109.9	0.7	5	4	1	32	42	52	86.7	86.8	87.2
8	14	16	30	1014.1	92	76.3	106.5	89.1	76.5	109.1	88	80.4	112.6	5.8	7	5	1	37	52		83.9	84.3	87.6
8	14	17	0	1013.7	94.5	77.8	111.3	90.3	77.9	113.2	90	81.5	111.7	2.7	8	4	1	37	51	55	86.2	86.2	88.4
8	14	17	30	1013.3	96.3	79.3	118	92.5	79.5	117.3	93.2	84.4	115.7	2.2	7	4	1	37	50		88.7	88.4	91.5
8	14	18	0	1012.8	99.3	80.3	126	93.4	80.1	124.4	92.7	84	118.8	3.5	4	4	0	34	48	54	91.3	90.3	91.8
8	14	18	30	1012.6	97	79.3	112.3	92	79.8	112.9	91.6	82.9	113.2	2.5	4	2	1	38	53		87.7	87.6	89.8
8	14	19	0	1012.3	94	77.5	110.5	91.3	78.8	109.1	89.8	82	113	3.1	4	2	1	39	54	57	85.8	86.1	89.0
8	14	19	30	1011.7	99.8	81.3	118.8	94	81.9	121.1	93.7	86.4	120.2	2.3	3	2	0	38	53		90.7	91.0	93.9
8	14	20	0	1011.7	100.8	80.8	122.8	94.7	81.5	123.4	95	86	121.6	2	3	2	0	33	49	56	91.2	91.2	94.0
8	14	20	30	1011	99	79.8	119	94.4	81	119.2	94.8	84	115.3	1.4	4	2	0	34	48		89.6	90.0	91.3
8	14	21	0	1011.3	96	78.8	115.5	92.9	79.9	116.2	92.7	82.8	114.8	2.2	4	2	0	34	49	56	87.9	88.5	90.2
8	14	21	30	1011.2	96	80	114.5	93.2	80.9	115	92.5	83.7	113.9	2.5	3	2	0	37	53		88.5	89.0	90.6
8	14	22	0	1011.2	93.5	78.3	110.3	91.4	79.5	111.3	89.6	82.2	113.2	4	3	2	0	39	55	56	86.2	87.1	89.1
8	14	22	30	1011.1	91	78.5	107.5	90.3	79.6	107.2	91	82.4	107.1	1.8	2	3	0	43	56		85.6	86.2	88.2
8	15	14	0	1014.1	88.8	73.5	105	84.2	74.1	105.1	83.8	77.7	103.6	1.9	4	4	1	45	57	51	81.3	81.3	83.5
8	15	14	30	1014.3	93	74	112	86.8	75.2	113.9	87.4	79.7	111.6	2.2	5	4	0	34	50		83.5	84.1	86.9
8	15	15	0	1014.3	93.5	75.8	116.5	88.5	77	117.4	91.4	80.1	108.7	0.2	4	5	1	31	42	49	85.7	86.2	87.0
8	15	15	30	1014.3	94.3	74.5	115.5	88.7	75.5	115.3	87.8	78.4	114.8	3.2	5	5	0	33	45		84.7	84.8	86.6
8	15	16	0	1014.2	93	74.8	114.5	89	75.8	112.1	88.9	78.6	109.4	1.8	5	5	1	35	47	44	84.6	84.4	85.8
8	15	16	30	1013.8	94	76	116	90.4	76.7	116.9	89.2	80.2	114.3	3.2	4	5	0	33	47		85.8	86.1	87.9
8	15	17	0	1013.3	94.3	76	114.3	91.1	76.9	115.4	89.6	80.2	117.5	3.9	4	5	0	34	46	43	85.5	86.0	88.6
8	15	18	0	1012.8	94	75.8	107	91.1	77.4	106.5	90.5	78.8	104.4	2	4	2	2	36	49	48	83.9	84.6	85.1
8	15	18	30	1012.5	100	79.3	120	94.6	79.7	120.4	94.8	84.9	122.7	2.6	3	2	0	33	45		89.5	89.3	93.5
8	15	19	0	1012.5	100	78.8	120	94.8	79.5	122.1	94.3	84	123.4	3	4	2	0	31	44	49	89.2	89.6	92.9
8	15	19	30	1012.5	94.8	76.8	107	91.8	77.7	108.6	92.5	81	111.4	3	3	2	1	36	46		84.6	85.3	88.2
8	15	20	0	1012.3	95.3	77.5	111	92.1	78.2	111.9	91.8	81.9	113.7	4.1	2	2	0	36	49	51	86.0	86.3	89.3
8	15	20	30	1012.2	94.5	76.8	110	91.4	78	110.7	91.6	80.8	110.8	3.6	2	4	0	37	48		85.2	85.9	87.9
8	15	21	0	1012.1	94.8	77.5	112	91.6	78.6	112.3	91.8	82.2	113.2	3.7	3	4	0	38	50	51	86.1	86.6	89.4
8	15	21	30	1012.1	93.3	77.5	110.5	91.1	78.9	111.4	91.4	81.9	110.7	2.9	3	4	0	38	51		85.7	86.6	88.6
8	15	22	0	1012	90.5	76	105.3	89.5	77.3	106.5	89.2	79.7	107.4	3.5	4	4	1	40	52	52	83.3	84.4	86.2

Notes: All observations were taken at 30.49° N, 86.52° W (Eglin AFB). Local time = GMT – 5 h.

<sup>a</sup> 0 = none; 1 = stratocumulus; 2 = cumulus; 3 = altostratus/altocumulus; 5 = thin cirrus; 6 = thick cirrus; 7 = precipitation.

<sup>b</sup> 0 = sun not obscured; 1 = sun partially obscured; 2 = sun obscured.

<sup>c</sup> National Weather Service observation site at the Northwest Florida Regional Airport (Valparaiso), less than 1 mile south-southwest of the WBGT observation site.



**Table 1c WBG T and Meteorological Data for Quest, Sigma 1 (S1), and Kestrel 2 (K2) Sensors**

Mon	Day	Hour	Min	Pressure millibars	SIGMA 1			QUEST			KESTREL 2			Wind mph	Cld amt tenths	Cld type code <sup>a</sup>	Obscuration code <sup>b</sup>	Quest RH %	Kestrel RH %	VPS <sup>c</sup> RH %	S1 WBG T deg F	Q WBG T deg F	K2 WBG T deg F
					Dry deg F	Nat Wet deg F	Globe deg F	Dry deg F	Nat Wet deg F	Globe deg F	Dry deg F	Nat Wet deg F	Globe deg F										
		GMT																					
8	15	22	30	1011.9	90	75.8	104.5	89.5	77	105.6	88	79.2	106.5	5.4	3	4	1	42	53		83.0	84.0	85.5
8	16	15	30	1015.4	95.8	78.5	123.3	93.1	79.2	120.4	99.3	84.9	115.7	1.3	2	2	0	31	40		89.2	88.8	92.5
8	16	16	0	1015.3	96.5	78.3	117.3	92.6	79.5	119.6	93.4	84.2	122.2	2.2	4	2	0	33	44		87.9	88.8	92.7
8	16	16	35	1015.3	99	81.5	122.3	94.9	81.6	122.3	95.4	85.8	120.7	2.2	5	2	0	30	47		91.4	91.1	93.7
8	16	17	0	1015.3	94.8	80.3	111.3	92.2	81	110.1	92.3	82.9	108.3	2.4	6	2	1	39	54	59	88.0	87.9	88.9
8	16	17	30	1014.9	90.3	78.5	103.3	90.3	79.7	101.5	89.2	82.6	109	2.6	6	2	2	40	60		84.6	85.1	88.5
8	16	18	0	1014.8	95.8	81.8	116	93.2	81.5	114.5	92.8	84.9	113.5	3.8	6	2	1	40	56	59	90.0	89.3	91.4
8	16	18	30	1014.6	96.5	81	109.3	92.7	81.4	112.1	93.2	84.2	108.7	3.2	6	2	2	46	54		88.2	88.7	90.0
8	16	19	0	1014.6	98.5	81.3	113.8	93.8	81.7	116.4	93.7	86.2	115.3	3.3	6	2	1	40	54	56	89.5	89.9	92.8
8	16	19	30	1014.2	97.3	79.5	110	93.6	80.7	113.7	93.7	84	112.3	3.6	6	2	1	39	52		87.4	88.6	90.6
8	16	20	0	1013.9	99.3	82.3	113	94.7	83.2	116.1	94.8	86.2	114.8	4	6	2	0	41	53	56	90.1	90.9	92.8
8	16	20	30	1013.7	97	81.3	114	93.8	82.2	115.9	93.9	86.4	118	4.2	5	2	0	40	55		89.4	90.1	93.5
8	18	14	0	1014.3	87.5	80.8	109	86.6	81.5	108.9	90.1	86.4	108.1	2.3	3	2	0	51	69	78	87.1	87.5	91.1
8	18	14	30	1014.5	89.5	80.3	109	88.4	81.5	106.4	88.2	85.1	106.5	2	5	2	1	46	71		87.0	87.2	89.7
8	18	15	0	1014.8	92.8	82	119.5	90.9	82.1	116.9	90.7	85.5	111.9	2.6	5	2	0	38	62	68	90.6	89.9	91.3
8	18	15	30	1014.6	93	80.8	110.5	91	81.1	109.9	92.7	84	107.8	2.1	6	2	1	38	57		88.0	87.9	89.6
8	18	16	0	1014.3	92.3	81	117.5	91.8	81.6	111.3	92.5	85.5	109.9	1.8	8	2	1	37	59	66	89.4	88.6	91.1
8	18	16	30	1014.2	89	81.3	105	89.3	81.5	98.8	88.2	85.1	108.3	4.4	8	2	2	48	70		86.8	85.7	90.1
8	18	17	0	1013.8	93.3	82.5	116.5	91.8	82.1	110.9	90.3	84.9	110.1	6.8	8	2	1	47	62	66	90.4	88.8	90.5
8	18	17	30	1013.6	93.3	82	117.3	91.6	81.5	110.3	90.5	84.7	111.6	5.1	8	2	1	44	61		90.2	88.3	90.7
8	18	19	30	1012.8	80	76	86.5	79	76.4	88	79.9	77.2	82.2	0.5	9	3	2	78	84		78.5	79.0	78.5
8	18	20	0	1012.4	84.8	78.5	94	82.2	78.9	95.6	83.7	82.2	91.9	0.2	9	3	2	70	81	84	82.2	82.6	84.3
8	18	20	30	1012.2	87	80.5	96.8	84.6	81	98.1	86.5	83.1	95.2	0.9	9	3	2	69	77		84.4	84.8	85.9
8	18	21	0	1012.4	89.5	81.5	99.5	86.3	82.3	101.5	88.3	84.9	98.1	0.5	9	3	2	65	75	79	85.9	86.5	87.9
8	19	14	0	1013.9	85	80	90	84.7	80.6	90.5	84.4	79.9	90.3	1.4	7	2	2	71	81	78	82.5	83.0	82.4
8	19	14	30	1013.7	89.3	81.8	103	87	82.1	106.5	89.2	86.9	104	3.1	5	2	0	62	74		86.8	87.5	90.6
8	19	15	0	1013.8	90.3	81.3	112	89.3	82	111.5	89.4	86.9	111	3.4	4	2	0	44	70	70	88.3	88.6	92.0
8	19	15	30	1013.9	91.5	80.8	108.8	89.7	81.5	111.1	88.9	84.4	106.9	5.9	5	2	1	46	67		87.5	88.2	89.4
8	19	16	0	1013.6	93.8	81.5	114	91.2	81.9	114.3	90	86.7	119.5	3.6	5	2	0	40	63	64	89.2	89.3	93.6
8	19	17	35	1013.1	92.8	85.3	128	90	84.1	120.2	88.7	88.7	112.6	3.4	6	2	0	50	75		94.6	91.9	93.5
8	19	18	0	1012.7	90.8	80.3	109.3	89.8	80.6	104.2	89.1	83.1	103.5	3.6	8	2	1	46	66	62	87.2	86.2	87.8
8	19	18	30	1012.5	93.8	81.8	106.3	90.8	81.9	109.9	90.1	85.8	112.1	7.2	5	2	0	48	65		87.9	88.4	91.5
8	19	19	0	1012.3	94.3	80.5	105.5	91.3	80.5	108.6	90.7	83.8	112.3	6.3	4	2	0	44	58	56	86.9	87.2	90.2
8	19	19	30	1011.9	94	81	108.3	91.5	81.4	110.7	91	85.3	112.5	5.3	3	2	0	45	61		87.8	88.3	91.3
8	19	20	0	1011.7	94.3	80.8	107	91.5	81.1	110.2	91.6	84	110.7	4.2	4	2	0	43	57	57	87.4	88.0	90.1
8	19	20	30	1011.6	92.3	80	102.8	90.3	80.8	106.1	90.1	84.4	108.3	6.8	3	2	0	48	63		85.8	86.8	89.8
8	19	21	0	1011.5	92	79.3	103	90.4	80	105.9	90.1	82.8	107.1	5.8	3	5	0	47	59	60	85.3	86.2	88.4
8	19	21	30	1011.4	92.8	79.8	104	91	80.6	107.5	91	83.5	109.2	5.9	3	5	0	47	58		85.9	87.0	89.4
8	19	22	0	1011.3	90.3	79.5	100.3	89.6	80.3	103.1	89.2	82.2	103.8	5.9	3	5	0	51	62	63	84.7	85.8	87.2

Notes: All observations were taken at 30.49° N, 86.52° W (Eglin AFB). Local time = GMT – 5 h.

<sup>a</sup> 0 = none; 1 = stratocumulus; 2 = cumulus; 3 = altostratus/altocumulus; 5 = thin cirrus; 6 = thick cirrus; 7 = precipitation.

<sup>b</sup> 0 = sun not obscured; 1 = sun partially obscured; 2 = sun obscured.

<sup>c</sup> National Weather Service observation site at the Northwest Florida Regional Airport (Valparaiso), less than 1 mile south–southwest of the WBG T observation site.

Table 2a WBGT and Meteorological Data for Quest, Sigma 2 (S2), and Kestrel 1 (K1) Sensors

Mon	Day	Hour	Min	Pressure millibars	SIGMA 2			QUEST			KESTREL 1			Wind mph	Cld amt tenths	Cld type code <sup>a</sup>	Obscuration code <sup>b</sup>	Quest RH %	Kestrel RH %	VPS <sup>c</sup> RH %	S2 WBGT deg F	Q WBGT deg F	K1 WBGT deg F
					Dry deg F	Nat Wet deg F	Globe deg F	Dry deg F	Nat Wet deg F	Globe deg F	Dry deg F	Nat Wet deg F	Globe deg F										
8	20	14	0	1015.7	87.3	79.8	104.8	86	80.6	105.7	86.9	88.2	105.3	2.7	1	5	0	54	86	74	85.6	86.2	91.5
8	20	14	30	1016	90	81.3	110.8	88.7	81.9	111.3	87.8	89.2	112.1	3.6	2	2	0	45	82		88.1	88.5	93.6
8	20	15	0	1016.2	93	82.8	114.3	90.3	83	115.1	92.1	90.9	109.8	1.5	4	2	1	44	75	68	90.1	90.2	94.8
8	20	15	30	1016.2	95.5	83	120	92.6	83.6	120	92.1	90.7	118.8	3.4	4	2	0	39	71		91.7	91.8	96.5
8	20	16	0	1016.5	91	79.8	102	88.8	81.1	103.6	88.3	84.4	102.6	2.6	4	2	1	53	73	59	85.4	86.4	88.4
8	20	16	30	1016.3	98.5	84	122.3	94.3	83.4	121.5	96.4	91.2	118.2	1.3	5	2	0	40	61		93.1	92.1	97.1
8	20	17	0	1015.9	99	83.3	119.3	94.6	82.3	118.3	92.7	85.6	110.7	2.8	5	2	0	36	59	64	92.1	90.7	91.3
8	20	17	30	1015.7	100.5	86.8	128.5	95.9	85.2	123.7	93.6	92.3	125.2	3.7	7	2	0	40	68		96.5	94.0	99.0
8	20	18	0	1015.7	93.5	79.8	109	92.2	80.7	109.5	90.5	85.3	111.9	3.5	8	2	2	42	63	67	87.0	87.6	91.1
8	20	21	50	1014.9	76	72.5	76	75	72.7	76.1	75.2	72.5	76.1	0.6	9	3	2	89	87	87	73.6	73.6	73.5
8	20	22	15	1014.8	75.5	73.5	76	74.7	73.7	76.2	75	73.8	75.9	0	9	3	2	95	95		74.2	74.3	74.3
8	21	14	0	1018.4	86.3	80.8	103.3	85	81.3	102.8	83.8	86.4	103.8	5.3	2	4	0	67	91	81	85.9	86.0	89.6
8	21	14	30	1018.2	91.3	81.8	108.5	86.9	82.2	106.8	85.6	87.8	107.1	4	2	4	0	62	87		88.1	87.6	91.4
8	21	15	0	1018.2	94	82	110	87.9	82.1	108.7	86.7	87.4	109	4.4	1	4	0	59	81	73	88.8	88.0	91.7
8	21	15	30	1018.2	94	81.3	114	89.5	81.8	112.8	87.8	87.4	112.3	5.3	1	2	0	51	75		89.1	88.8	92.4
8	21	16	0	1018.1	96.5	82.3	117	90.9	82.6	116.5	89.4	89.8	117.5	2.9	2	2	0	46	75	63	90.7	90.2	95.3
8	21	16	30	1017.7	100.3	83	127.8	94	83.6	125.9	92.7	91.6	122.5	1.6	3	2	0	37	67		93.7	93.1	97.9
8	21	17	0	1017.5	104.5	83.5	121.3	94	83.9	125.6	93.6	89.2	115.5	1.3	4	2	0	42	62	59	93.2	93.3	94.9
8	21	17	30	1017.4	101.3	87	122.3	95.9	86.5	123.5	94.3	91.6	117.3	2.4	4	2	0	43	69		95.5	94.8	97.0
8	21	18	0	1017.2	101.5	86	121.5	94.5	85.8	120.9	93.4	92.8	121.3	2.7	3	2	0	46	72	68	94.7	93.7	98.6
8	21	18	30	1017.2	101.5	86.3	120.8	94.8	86.1	120.6	93.9	92.8	119.5	2.3	3	2	0	46	73		94.7	93.9	98.3
8	21	19	0	1016.7	102.5	86.5	121.8	95.4	86.3	122.7	94.5	93	122.2	2.2	4	2	0	44	71	68	95.2	94.5	99.0
8	21	20	10	1015.6	98	83.8	113.3	93.7	84.8	114	93	91.4	117.1	2.5	5	2	0	44	73		91.1	91.5	96.7
8	21	21	0	1015.2	93.3	81	105	89.8	81.6	106	89.2	85.8	102.6	1.6	5	2	1	49	74	65	87.0	87.3	89.5
8	21	21	30	1015.2	96	82.3	111.8	92.1	82.8	113.5	91.2	88.9	112.6	2.5	5	2	0	43	72		89.6	89.9	93.9
8	21	22	0	1015.3	97	82.3	113.8	93.1	83.4	115.8	91.4	88	115.7	2.6	4	2	0	42	67	64	90.1	90.9	93.9
8	21	22	25	1015.3	95.8	82	109.8	92.4	83.1	112.3	91	87.8	112.1	2.6	5	4	1	44	71		88.9	89.9	93.0
8	22	14	0	1016.5	90	79.8	106.5	87.4	81	106.3	86.4	85.3	106.3	3.2	0	0	0	57	77	67	86.2	86.7	89.6
8	22	14	30	1016.6	92	80.5	108.3	88.4	81.3	107.9	87.3	86.5	109.6	4.8	0	0	0	54	76		87.2	87.3	91.2
8	22	15	35	1016.7	98.8	82	116.3	92.7	82.8	114.1	91.4	87.1	113.5	3.4	0	0	0	46	64		90.5	90.1	92.8
8	22	16	0	1016.7	98	81.5	117.5	93.4	82.4	116.5	91.8	87.3	117.9	4.4	0	0	0	43	62	55	90.4	90.3	93.9
8	22	16	30	1016.5	100	81	117.3	93.9	81.8	113.7	93.2	87.6	117.3	5.6	4	2	0	45	60		90.2	89.4	94.1
8	22	17	0	1016.1	99	81.8	119.8	95.3	82.7	120.2	93.9	88.3	121.6	3.8	6	2	0	35	58	49	91.1	91.5	95.5
8	22	17	30	1015.9	94.8	79	107	93.4	80.5	104.9	92.7	83.3	106.3	2	8	2	2	39	57		86.2	86.7	88.8
8	22	18	0	1015.5	104.3	83	135.5	99.3	83.4	131.5	97.2	90.5	133.7	2.5	8	2	0	28	50		95.6	94.6	99.8
8	22	18	30	1015.4	96.8	79.8	102.3	94.1	81.1	103.6	94.8	83.1	101.1	0	9	2	2	40	53		86.0	86.9	87.9
8	22	19	0	1014.7	93	80.5	97.8	91.9	81.7	98.4	91.2	83.1	100	2.8	8	2	2	50	65		85.2	86.1	87.3
8	22	19	30	1014.4	96.3	82	105.5	93.9	83.1	105.7	93	87.4	109.9	2	9	2	2	44	66		88.1	88.7	92.5

Notes: All observations were taken at 30.49° N, 86.52° W (Eglin AFB). Local time = GMT – 5 h.

<sup>a</sup> 0 = none; 1 = stratocumulus; 2 = cumulus; 3 = altostratus/altocumulus; 5 = thin cirrus; 6 = thick cirrus; 7 = precipitation.

<sup>b</sup> 0 = sun not obscured; 1 = sun partially obscured; 2 = sun obscured.

<sup>c</sup> National Weather Service observation site at the Northwest Florida Regional Airport (Valparaiso), less than 1 mile south–southwest of the WBGT observation site.



**Table 2b WBGT and Meteorological Data for Quest, Sigma 2(S2), and Kestrel 1 (K1) Sensors**

					SIGMA 2			QUEST			KESTREL 1													
Mon	Day	Hour	Min	Pressure	Dry	Nat Wet	Globe	Dry	Nat Wet	Globe	Dry	Nat Wet	Globe	Wind	Cld amt	Cld type	Obscuration	Quest RH	Kestrel RH	VPS <sup>c</sup> RH	S2 WBGT	Q WBGT	K1 WBGT	
		GMT		millibars	deg F	deg F	deg F	deg F	deg F	deg F	deg F	deg F	deg F	mph	tenths	code <sup>a</sup>	code <sup>b</sup>	%	%	%	deg F	deg F	deg F	
8	22	20	0	1013.9	100.5	82.5	116	96.4	83.3	116.9	94.8	89.1	120.2	3.4	8	2	1	38	60		91.0	91.3	95.9	
8	22	20	30	1013.5	102.5	82.5	119.3	97.6	83.6	121.8	95.5	88.5	121.6	4.1	7	2	0	35	56		91.9	92.6	95.8	
8	22	21	0	1013.6	102	82.5	118.8	97.7	84	120.8	96.6	88.3	119.1	2.6	6	2	0	34	56		91.7	92.7	95.3	
8	22	21	30	1013.4	99	82.5	114.8	96	83.8	116.6	96.4	90.1	117	2	7	2	0	40	61		90.6	91.6	96.1	
8	22	22	0	1013.3	95	83.3	107.8	93.3	84	109.8	92.3	88.7	109.2	4.6	6	2	0	51	72		89.4	90.1	93.2	
8	23	14	35	1013.6	95.8	82	112.5	91.7	82.3	111.8	90.1	86.5	110.5	2.9	2	5	0	53	68		89.5	89.1	91.7	
8	23	15	0	1013.5	97	81.3	113.3	92.4	82.2	111.9	90.5	85.6	111	5.2	2	5	0	49	64	57	89.3	89.2	91.2	
8	23	15	30	1013.5	98	80.8	116	93.9	82.1	114.7	92.1	86.4	115.5	5.6	2	5	0	43	60		89.6	89.8	92.8	
8	23	16	30	1013.2				96.2	81.3	122.8	94.5	87.4	124.3	4.7	4	2	0	34	53			91.1	95.5	
8	23	16	55	1012.9				97.1	82.2	124.1	95.4	87.6	124.7	5	5	2	0	36	52	45		92.1	95.8	
8	23	17	25	1012.6				98.2	82.6	127.5	98.4	88	121.6	1.1	6	2	0	32	46			93.1	95.8	
8	23	17	55	1012.1				99.1	81.8	130.5	95.9	87.1	128.1	2.6	6	2	0	30	47	43		93.3	96.2	
8	23	18	20	1011.9				99.1	81.6	128	97	88	128.7	4.9	7	2	0	29	47			92.6	97.0	

Notes: All observations were taken at 30.49° N, 86.52° W (Eglin AFB). Local time = GMT – 5 h.

<sup>a</sup> 0 = none; 1 = stratocumulus; 2 = cumulus; 3 = altostratus/altocumulus; 5 = thin cirrus; 6 = thick cirrus; 7 = precipitation.

<sup>b</sup> 0 = sun not obscured; 1 = sun partially obscured; 2 = sun obscured.

<sup>c</sup> National Weather Service observation site at the Northwest Florida Regional Airport (Valparaiso), less than 1 mile south–southwest of the WBGT observation site.

## 5. References

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